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Determination of Natural and Artificial Radionuclides in Water Samples of Habigonj District, Bangladesh

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Abstract
The specific activities of natural and artificial radionuclides in 8 Water samples collected from Habiganj district in Bangladesh, have been Studied and evaluated. Experimental results were obtained by using a High Purity Germanium (HPGe) Detector and the radioactive standard sources supplied by IAEA were used to determine the efficiency. The measuring time of all samples is 5000 seconds. It was found that, the water specific activity ranges from 1.4470 ± 0.00281 - 13.0836 ± 0.00335 Bq/kg for Radium-226 (^{226}Ra), 0.0 - 14.0196 ± 0.00265 Bq/kg for Thorium-232 (^{232}Th) and 0.0 - 73.4632 ± 0.006899 Bq/kg for Potassium-40 (^{40}K), with mean values of 5.6947 ± 0.00278 Bq/kg, 6.2259 ± 0.00177 Bq/kg and 24.6966 ± 0.00426 Bq/kg respectively. It was also found that there is no artificial radionuclide (^{137}Cs) in any kind of samples of Habiganj district. In order to evaluate the radiological hazard of the natural and artificial radioactivity, Radium equivalent activity (Ra_{eq}), gamma absorbed dose rate, the external hazard index (H_{ex}), annual effective dose rate for different water samples were calculated 16.25248 Bq/Kg, 7.397393 nGy/h, 0.044364, 9.072163 µSv respectively.
Keywords: Habiganj, HPGe detector; Water, Natural Radionuclides, Artificial Radionuclides, ^{40}K, ^{137}Cs, ^{226}Ra, ^{232}Th.

1. INTRODUCTION

Radiation is common phenomenon in our life but we are not concerned about this phenomenon. Radionuclides (radioactive element) can be divided into natural and artificial radionuclides. Radionuclides are present all over the world. We found various amount of radioactivity in all of the elements of our environment like air, soil, water, food, industrial materials etc. Although radionuclides are just a mare material of environment it reminds us the use in medical science, nuclear power plant, industry as well as the horrible day of Hiroshima & Nagasaki. Radiation may be artificial or natural, or radiation dose may be small or large, it creates some biological effects. For these reason the whole world has became aware of radionuclides and many splendid works has been done monitoring radioactivity. Geographical position & natural resources of Habiganj is in the favour of radioactivity, there is no such information about radioactivity in Habiganj is present due to lack of measurement. For this reason, concentration of radionuclides in 8 water samples have been studied and evaluated.

2. MATERIALS AND METHODS

2.1. Description of study area

The district Habiganj is in the northeastern part of Bangladesh. Habiganj is located at 91°10'E-91°40'E longitude and at latitude 23°57'N-24°42'N. It is established as a district at 1 March 1984. It has 3 gas fields which are Habiganj, Bibiyana & Rashidpur gas field. Mineral sand is also found in Habiganj.The annual rainfall in this area is 3334 mm. Minimum and maximum temperature of Habiganj district varies from 13.6°C to 33.2°C. Rivers as well as streams and lakes are situated in Habiganj district. This district is vulnerable to both flood and drought.

2.2. Sampling and samples preparation

Water samples were collected during 2011 from 8 locations in the municipal area of Habiganj district in the north east of Bangladesh and kept in plastic bottles. Before doing so the bottles were washed carefully. All the samples were collected from surface water. The volume of each sample was 1 litre. Each sample was treated with 1N concentrated nitric acid and placed in water bath and hot plate in fume hood for volume reduction to 230-260 ml.

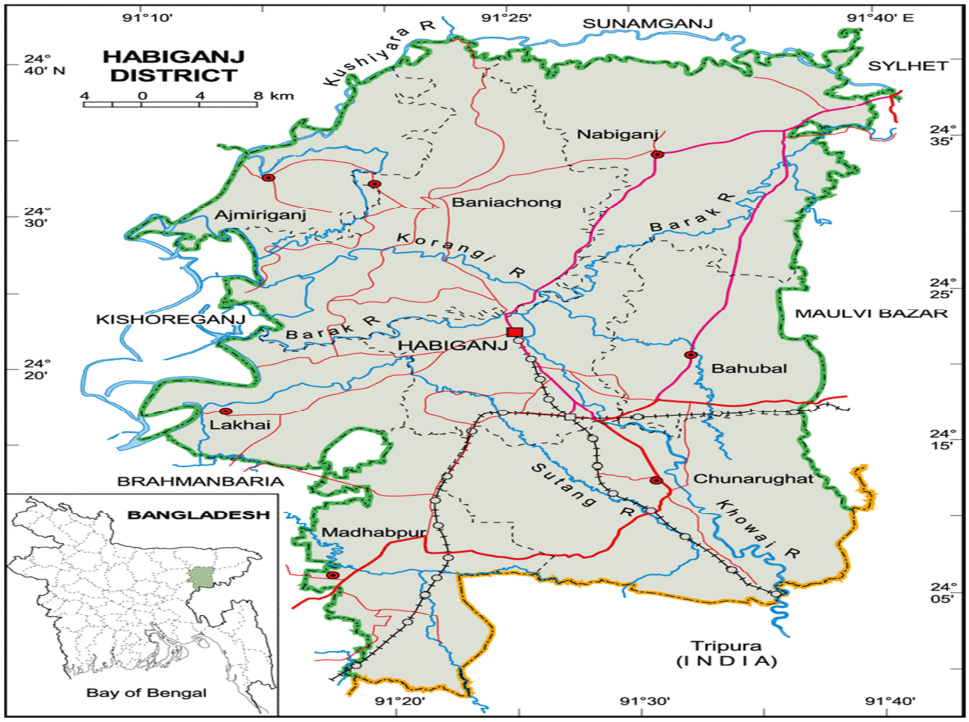

Fig. 1. Map of Habigonj District,Bangladesh. This map indicates the location of the Upazilas studied. Retrieved from: <https://www.google.com.bd/?gws_rd=cr,ssl&ei=-MXqVOSDG82i8AW684LYAQ#q=map+of+habiganj+district+bangladesh>

Table 1: Sample Codes and corresponding Locations of Habigonj District

Upazila	Name of Sample collected place	Type of water source	Sample ID
1. Habiganj sadar	Nurpur Govt. Primary School	Surface Water	HW1
2. Chunarughat	Agrani High School	Surface Water	CW2
3. Bahubal	Mirpur Girls High School	Surface Water	BW3
4. Lakhai	Kalaukh Sub Register Office	Surface Water	LW4
5. Baniachong	Baniachong Adarsha High School	Surface Water	BW5
6. Azmirigonj	Azmirigonj college	Surface Water	AW6
7. Nobigonj	Nobigonj Degree College	Surface Water	NW7
8. Madhabpur	Madhabpur Govt. Primary School	Surface Water	MW8

2.3. Experimental setup

Gamma spectroscopy system is applied to investigate water samples. The spectrometry system consisted of a high purity germanium (HPGe) detector, Pre-amplifier (supplied by Oxford instrument Inc. Nuclear measurement group, U.S.A), High voltage supplier (HV supply model ORTEC 459), Amplifier, MCA card memory containing a commercial software EMCAPLUS (silena) version 1.012 (supplied by silena, Germany). The contents of the memory after a measurement lasting 5000s can be displayed on a CRT screen of a monitor coupled with the PC. The digital recording of the content of each channel can be printed out through a printer (Model LQ-570+) supplied by EPSON, Japan. The resolution of the (HPGe) detector was found 2.80keV at FWHM of the 1332keV peak of ^{60}Co. The shielding arrangement surrounding the detector was fabricated in the form of a circular cylinder having 21 inch in height using lead and steel. The top was covered by round movable steel and a lead plate. ^{226}Ra activity of the samples was determined by the help of its daughters (^{214}Pb and ^{214}Bi) and ^{232}Th activity of the sample was determined by the help of its daughters (^{228}Ac). Average Radioactivity of different water samples were determined and are given in Table 2. The activity of each radionuclide ^{214}Pb, ^{214}Bi, ^{228}Ac, ^{40}K and were then calculated using the following formula:

$$A = \frac{N \times 100 \times 1000}{P_\gamma \times \varepsilon \times W} \quad \text{..... (1)}$$

Where,

N=Net counts per second (c.p.s) = (sample c.p.s-back ground c.p.s)

P γ =Probability of radionuclide
ε= Efficiency in%.
W=Weight of the sample in kg.

Table 2:Average Radioactivity of different water samples.

Upazila	Code	^{214}pb (351.92 keV) Bq/kg	^{214}Bi (609.31 keV) Bq/kg	^{214}Bi (1120.07 keV) Bq/kg	^{228}Ac (911.07 keV) Bq/kg	^{228}Ac (969.11 keV) Bq/kg	^{40}K (1460.8 keV) Bq/kg
1. Habiganj Sadar	HW1	0.7953 ± 0.000371	4.3598 ± 0.00261	2.8839 ± 0.00106	5.3398 ± 0.00144	4.5453± 0.00157	24.6966± 0.00426
2. Chunarughat	CW2						
3. Bahubal	BW3						
4. Lakhai	LW4						
5. Baniachong	BW5						
6. Azmirigonj	AW6						
7. Nobigonj	NW7						
8. Madhabpur	MW8						

3. RADIATION HAZARD INDICES CALCULATION

The distribution of ^{226}Ra, ^{232}Th and ^{40}K is not uniform. Uniformity with respect to exposure to radiation has been defined in terms of radium equivalent activity (Ra_{eq}) in Bq/kg to compare the specific activity of materials containing different amounts of ^{226}Ra, ^{232}Th and ^{40}K. It is calculated using the following relation (UNSCEAR, 2000):

$$Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.07C_K \quad \text{..... (2)}$$

Where C_{Ra}, C_{Th} and C_K are the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in Bq/kg, respectively. While defining Ra_{eq} activity according to Eq. (2), it has been assumed that 370 Bq/kg of ^{226}Ra or 259 Bq/ kg of ^{232}Th or 4810 Bq/kg of ^{40}K produce the same gamma dose rate.

The external gamma absorbed dose rate in the air at lm above ground level was calculated from the measured activities of ^{226}Ra, ^{232}Th and ^{40}K in samples assuming that the other radionuclides, such as ^{137}Cs, ^{90}Sr and the ^{235}U series can be neglected as they contribute very little to the total dose from environmental background. The calculations were performed according to the following equation (UNSCEAR, 2000):

$$D = 0.462C_{Ra} + 0.604C_{Th} + 0.042C_K \quad \text{..... (3)}$$

Where D is the dose rate in nGy/h and C_{Ra}. C_{Th} and C_K are the specific activities (Bq/kg) of ^{226}Ra, ^{232}Th and ^{40}K, respectively.

The external hazard index, H_{ex}, is defined as (UNSCEAR, 2000):

$$H_{ex} = C_{Ra}/370 + C_{Th}/259 + C_K/4810 \quad \text{..... (4)}$$

where C_{Ra}, C_{Th} and C_K are the specific activities (Bq/kg) of ^{226}Ra, ^{232}Th and ^{40}K, respectively. The value of this index must be less than unity in order to keep the radiation hazard insignificant. The maximum value of H_{ex} equal to unity.

To estimate annual effective dose rates, the conversion coefficient from absorbed dose in air to effective dose ($0.7SvGy^{-1}$) and an outdoor occupancy factor (0.2) proposed by UNSCEAR, 2000 are used. Therefore, the annual effective dose rate ($mSvy^{-1}$) was calculated by the formula (UNSCEAR, 2000):

$$D_{eff}(Sv) = D(nGy/h) \times (24 \times 365)(h) \times 0.7 \times 0.2 \quad \text{..... (5)}$$

4. RESULTS & DISCUSSION

The results of the measurements for 8 water samples collected at different locations in Habiganj District. It was found that, the water specific activity ranges from 1.4470 ±0.00281- 13.0836 ±0.00335 Bq/kg for Radium-226 (^{226}Ra), 0.0-14.0196 ±0.00265 Bq/kg for Thorium-232 (^{232}Th) and 0.0 - 73.4632±0.006899 Bq/kg for Potassium-40 (^{40}K), with mean values of 5.6947 ± 0.00278 Bq/kg, 6.2259 ± 0.00177 Bq/kg and 24.6966 ± 0.00426 Bq/kg respectively. We did not get artificial radionuclide (^{137}Cs) in any kind of samples of Habiganj district. Radium equivalent activity(Ra_{eq}) , gamma absorbed dose rate , The external hazard index(H_{ex}) , annual effective dose rate for different water samples were 16.25248 Bq/Kg , 7.397393 nGy/h , 0.044364 , 9.072163 µSv respectively.

Table 3: Specific activities of radionuclides (^{226}Ra, ^{40}K, ^{232}Th) in water samples at different locations in Habiganj District.

Location	Sample code	Radioactivity of ^{226}Ra (Bq/kg)	Radioactivity of ^{232}Th (Bq/kg)	Radioactivity of ^{40}K (Bq/kg)
1. Habiganj Sadar	HW1	1.4470±0.00281	9.7635±0.00243	0
2. Chunarughat	CW2	1.7875±0.00284	0	0
3. Bahubal	BW3	4.6508±0.002535	6.0334±0.0025	0
4. Lakhai	LW4	6.4969±0.00215	1.3606±0.00201	6.8599±0.006732
5. Baniachong	BW5	3.9891±0.00298	12.4048±0.002245	46.9072±0.006856
6. Azmirigonj	AW6	13.0836±0.00335	0	73.4632±0.006899
7. Nobigonj	NW7	6.6679±0.00255	14.0196±0.00265	53.3413±0.00687
8. Madhabpur	MW8	7.4354±0.003024	5.8108±0.00240	17.0014±0.006747
Mean		5.6947±0.00278	6.2259±0.00177	24.6966±0.00426

Table 4: Radium equivalent activity (Ra_{eq}), gamma absorbed dose rate, the external hazard index (H_{ex}), annual effective dose rate for different water samples in Habiganj.

Location	Sample code	Radium Equivalent Activity, Ra_{eq}(Bq/Kg)	Dose Rate, D (nGy/h)	External Hazard Index H_{ex}	Annual Effective Dose, D_{eff} (10^{-6} Sv)
1. Habiganj Sadar	HW1	15.40881	6.565668	0.041608	8.052135
2. Chunarughat	CW2	1.7875	0.825825	0.004831	1.012792
3. Bahubal	BW3	13.27856	5.792843	0.035865	7.104343
4. Lakhai	LW4	8.922751	4.111486	0.024239	5.042326
5. Baniachong	BW5	25.01147	11.30557	0.068428	13.86515
6. Azmirigonj	AW6	18.22602	9.130078	0.050634	11.19713
7. Nobigonj	NW7	30.44982	13.78874	0.083241	16.91051
8. Madhabpur	MW8	16.93494	7.658937	0.046066	9.39292
Mean		16.25248	7.397393	0.044364	9.072163

5. CONCLUSION

Habiganj district is one of the border districts of Bangladesh. Although it is important both geologically and from the view point of natural resources , information about radioactivity in Habiganj in present is still unavailable due to lack of measurement. For this reason, concentration of radionuclides in 8 water samples have been studied and evaluated.

For water samples Radium equivalent activity (Ra_{eq}), gamma absorbed dose rate, The external hazard index (H_{ex}), annual effective dose rate were 16.25248 Bq/Kg , 7.397393 nGy/h , 0.044364 , 9.072163 µSv respectively. The average value of gamma dose rate obtained in this study is less than to the world average 57 nGy/h. All values obtained for radium equivalent activity are less than 370 Bq/kg, which are acceptable for safe use OECD 1979.We did not get artificial radionuclide (^{137}Cs) in any kind of samples of Habiganj district.

This radioactivity monitoring study is significantly devoted to measure the effective dose to the environment where people live in. This type of study may be continued to establish a complete database of environmental radioactivity dissymmetry. This study may lead scientists or researchers to improve necessary safety measure.

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